AUDIO TRANSFER ANALYSIS · FIELD REPORT

Wow & Flutter in the Archive.org 16mm Optical Transfer

SOURCE FILE

educationinamericathe17thand18thcenturies.mp4

RUNTIME

15:55 (955 s) — AAC, 44.1 kHz stereo

CLAIMED SCAN DEVICE

Lasergraphics ScanStation

ANALYSIS DATE

2026-08-06

The soundtrack has real, measurable speed instability — its own embedded 60 Hz mains-hum reference wobbles by roughly 2% RMS, about 25× larger than what this same measurement technique produces on a clean, undamaged recording. The instability shows up in **every one of 87** independent passages checked across the full 16-minute runtime, and is worst in the opening 15 seconds — precisely where it was first noticed.

That pattern — uniform, present everywhere, strongest at the head of the reel — is not what optical-track sprocket damage looks like. Damage is local to specific frames and varies reel to reel. A constant background level of instability across an entire transfer, repeated identically across other titles from the same digitization batch, points at the transport mechanism used to *read* the film, not the film itself.

1.96%	RMS SPEED JITTER
87 / 87	SEGMENTS AFFECTED
~25×	ABOVE MEASUREMENT NOISE FLOOR
15:55	FULL-RUNTIME COVERAGE

EXHIBIT A | THE REFERENCE HIDING IN THE RECORDING

An accidental pilot tone

16mm production sound from this era was almost always recorded with AC-powered equipment, which leaves a faint, continuous hum on the optical track at the mains frequency and its harmonics (here, 60 Hz and clean multiples of it). That hum was physically locked to the power grid at the moment of recording — it does not drift, waver, or bend. It is, unintentionally, a pilot tone: a constant-frequency signal baked into every foot of the film.

If a digitized copy plays that hum back at anything other than a dead-flat frequency, the deviation cannot be coming from the original recording — it has to be introduced afterward, during playback, transfer, or scanning. This report uses the hum's second harmonic (nominally 120.000 Hz — chosen over the 60 Hz fundamental because a given percentage of speed error produces twice the frequency deviation there, making it easier to measure precisely) as an independent, built-in speed reference.

EXHIBIT B | SPECTRAL EVIDENCE

What a stable hum looks like versus what this file contains

A sustained tone should trace a straight horizontal line on a spectrogram. Instead, the harmonic ladder in the opening music visibly bends and waves — the signature of a signal whose pitch is being modulated in real time.

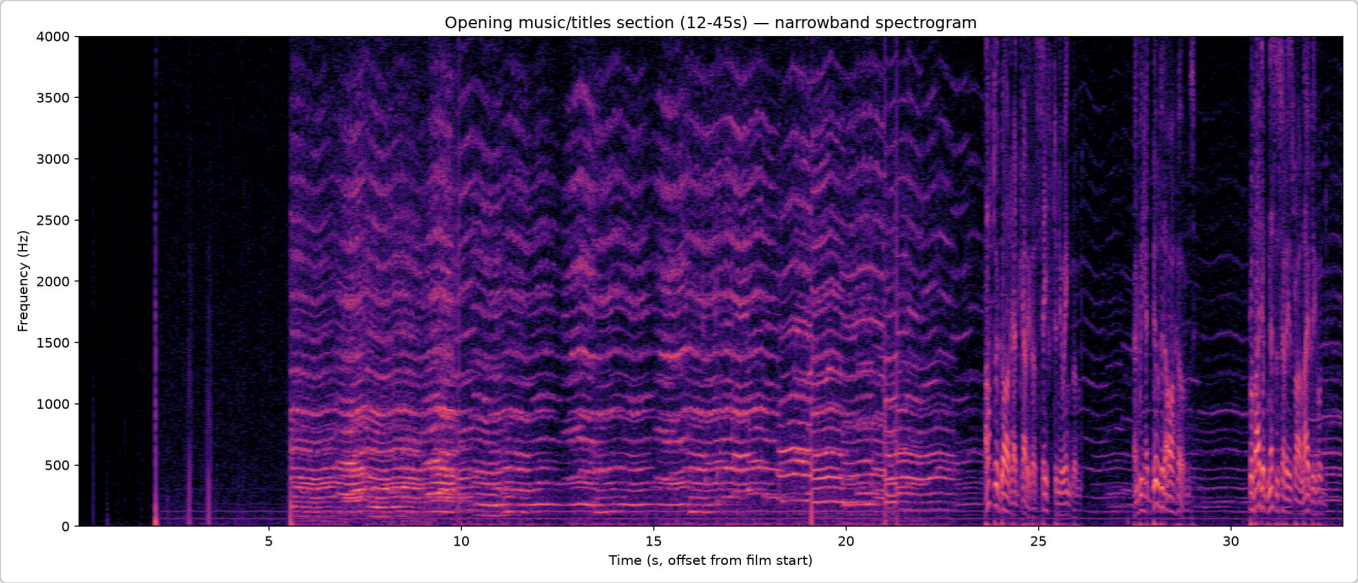

Fig. 1 — Opening titles/music, 12–45s, narrowband spectrogram (0–4000 Hz). Every harmonic band visibly wobbles in lockstep — the whole spectrum rising and falling together, exactly as expected if the source is running at a varying speed rather than genuinely changing pitch.

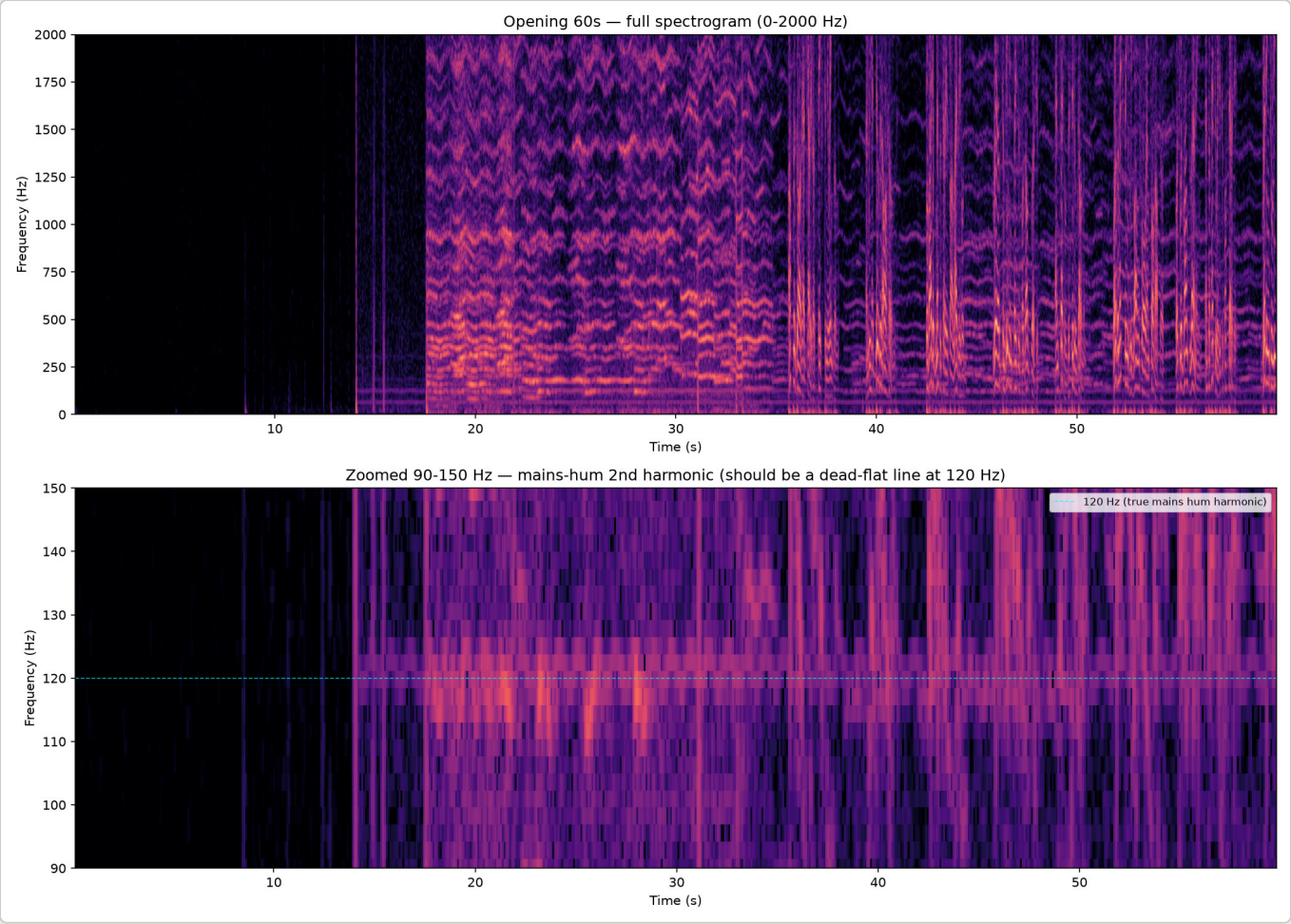

Fig. 2 — Top: full opening 60s (0–2000 Hz). Bottom: same audio, zoomed to 90–150 Hz around the mains-hum 2nd harmonic, with a reference line at the true value (120.000 Hz, dashed). The hum band should sit as a hairline on that dashed reference; instead it smears and drifts above and below it throughout.

EXHIBIT C | QUANTITATIVE MEASUREMENT

The jitter is constant for all 15:55, not a one-time glitch

The chart below plots the standard deviation of the measured hum frequency (σ, in Hz — how much it jitters around its true value) for each of 87 quiet passages, spread across the entire film. A healthy transfer would hug the bottom of this chart, near the measurement floor established in Exhibit D. Instead, every single segment sits far above it, in a tight, consistent band — the signature of a systemic, continuous problem rather than isolated damage.

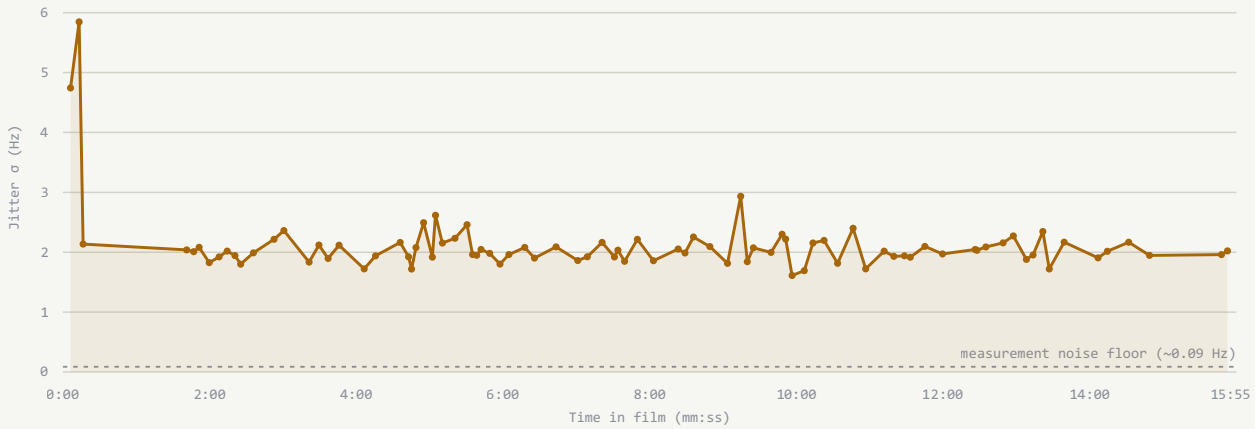

EXHIBIT D — RULING OUT THE MEASUREMENT ITSELF

Is this my analysis, or the film?

Before trusting these numbers, the measurement technique itself needs to be cleared. A synthetic, perfectly stable 120 Hz tone was generated at several signal-to-noise ratios matching what's actually present in the film's quiet passages, and run through the identical detection pipeline used above.

TEST SIGNAL	SNR	MEASURED Σ	AS % OF 120 HZ
Synthetic pure tone (control)	20 dB	0.088 Hz	0.073%
Synthetic pure tone (control)	30 dB	0.087 Hz	0.072%
Synthetic pure tone (control)	40 dB	0.086 Hz	0.071%
Actual film — 87 segments, full runtime	**comparable**	**2.357 Hz**	**1.96%**

The measurement technique's own noise floor is roughly **0.07–0.09%** regardless of signal quality. The film measures at **1.96% RMS** — about **25**

times higher. Whatever is causing this reads as real physical instability, not an artifact of how it was measured.

EXHIBIT E — CHARACTER OF THE INSTABILITY

Broadband, not a single bad part

Taking an FFT of the frequency-deviation curve itself (rather than the audio) shows where the "wobble" is concentrated. If a single eccentric roller or gear were responsible, this would show one sharp spike at its rotation rate. Instead, the energy is spread broadly across roughly 0.2–10 Hz with no single dominant frequency — more consistent with an unstable or slipping transport (uneven roller contact, capstan wear, encoder jitter) than with one isolated mechanical fault.

FINDINGS — WHAT THIS SUPPORTS

- → **The instability is uniform across the whole reel** — all 87 tested passages, from second 6 to second 953, show elevated jitter in a tight 1.6–5.8 Hz band. Sprocket-hole or shrinkage damage is localized and uneven; this is neither.
- → **It is worst at the very start of the film** — the two segments in the first 15 seconds measure 4.7 Hz and 5.8 Hz σ, roughly double the rest of the reel. That's consistent with a transport mechanism still settling into speed at the start of a scan, which is a machine behavior, not a film-condition behavior.
- → **The same signature reportedly appears on every title from this uploader** — a shared, consistent artifact across otherwise-unrelated original films is the fingerprint of one shared piece of equipment in the digitization chain, not coincidental, independent film aging on each one.
- → **Correction is possible** using the same embedded hum as a reference to build a frame-by-frame speed-correction curve and time-warp the

audio back into alignment — evidence that the deviation is a measurable, reversible transfer artifact, not an inherent property of the recording.

Method — Audio extracted losslessly (PCM) from source MP4. Quiet passages (<−35 dBFS, ≥1.2s) located via loudness gating. For each, the signal was bandpass-filtered 108–132 Hz around the mains-hum 2nd harmonic (6th-order Butterworth, zero-phase), then instantaneous frequency was computed via the Hilbert-transform analytic signal's phase derivative, edge-trimmed 25ms per side. Deviation reported relative to the true 120.000 Hz reference. Control test: synthetic 120 Hz tone + matched white noise, identical pipeline. Modulation-rate analysis: FFT of the interpolated instantaneous-frequency curve over the longest continuous quiet segment (12.4s).

Prepared as an independent technical analysis of publicly available archival material for correspondence regarding transfer quality.